Design Guide: Big Savings on Small HVAC Systems

The Problem

Small packaged heating, ventilation, and air-conditioning (HVAC) systems are among the most common HVAC systems for small commercial buildings. These systems, however, are notorious for a host of problems requiring 25 to 35 percent more energy than is necessary to heat, cool, and ventilate California buildings (see **Figure 1**). This poor performance results from inadequate design and installation as well as from poor maintenance and operating practices.

The Solution

The *Small HVAC System Design Guide,* available from the California Energy Commission, discusses solutions to common problems in the design, operation, and maintenance of small rooftop HVAC systems. It begins by emphasizing the importance of an integrated design approach; offers information on overall building design practices used to minimize HVAC loads; discusses the importance of selecting the proper unit size and how to design effective distribution and control systems; and concludes with discussions of commissioning, operation, and maintenance.

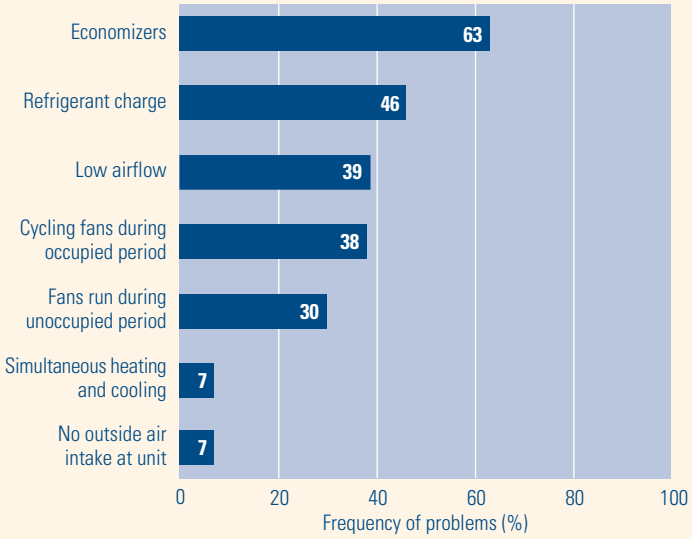
Features and Benefits

The guide outlines approaches to improving HVAC systems and overall building performance. The main recommendations are:

- Reduce load by using such strategies as reducing lighting power, using high-performance glass and skylights, adopting cool roofs, and increasing roof insulation (see **Figure 2**, next page).
- Specify reliable, factory-installed and -tested economizers with direct-drive actuators and low-leakage dampers.
- Specify commercial grade two-stage cooling thermostats with the ability to schedule fan operation and heating and cooling setpoints independently, ensuring continuous ventilation as required by code.
- Size HVAC units using ASHRAE-approved methods that account for the reduced loads achieved in the design phase, and make reasonable assumptions for plug load power and ventilation air quantities when sizing equipment.
- Specify right-sized high-efficiency units that meet Tier 2 efficiency standards established by the Consortium for Energy Efficiency (www.ceeformt.org).

Figure 1: Frequency of problems observed in the field

This graph shows how often various problems were observed in a field study of small rooftop HVAC systems conducted as part of the *Small HVAC System Design Guide* effort.



- Design distribution systems with lower air velocities to reduce pressure-drop and noise. Seal and insulate duct systems located outside the building's thermal envelope.
- Incorporate demand-controlled ventilation to reduce heating and cooling loads.
- Commission HVAC systems prior to occupancy. In particular, check the functioning of economizers, fans, and controls.
- Clearly define the services to be provided by HVAC maintenance personnel.

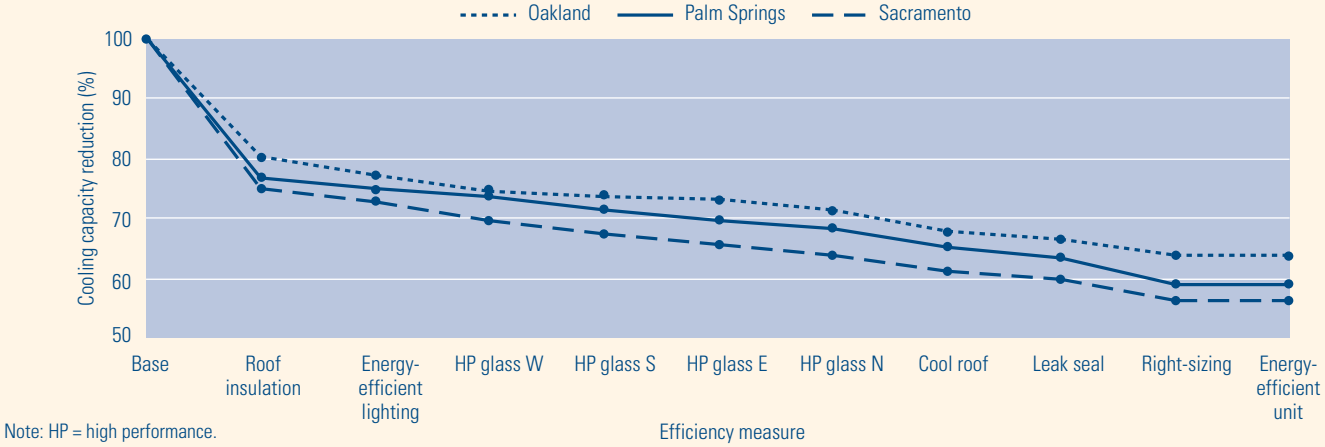
By applying the integrated design principles outlined in the guide, the energy consumption of buildings with small HVAC systems can be reduced by 25 to 35 percent without incurring significant increases in capital costs. These load-reduction strategies result in smaller and therefore less costly HVAC systems that have simple payback periods of 0.2 to 2.4 years. For example, following the recommended procedures for a typical building in Sacramento could cut the required cooling capacity by more than 40 percent, saving enough in HVAC capacity costs to almost completely cover the cost of the efficiency measures. The net result is a payback period of 5 months.

Applications

The HVAC systems discussed in the *Small HVAC System Design Guide* are single-package rooftop air conditioners and heat pumps

Figure 2: The impact of integrated design

It's possible to reduce HVAC system size by up to 40 percent, while reaping energy cost-savings of 25 to 30 percent, by implementing a series of efficiency measures using methods outlined in the *Small HVAC System Design Guide*.



Note: HP = high performance.

with a cooling capacity of 10 tons or less. The buildings that use these systems are often large facilities that must install multiple small systems to meet their cooling demand.

California Codes and Standards

The research that led to the development of the guide also played a significant role in two code changes to the California 2005 Title 24 standards: Acceptance Requirements for Nonresidential Buildings, and Nonresidential Duct Sealing and Insulation. The acceptance requirements include inspection checks and functional and performance testing to determine whether specific building components and systems will perform as expected. The duct-sealing and insulation initiative updated the treatment of duct systems that run outside of conditioned spaces in light commercial buildings. Tighter, better-insulated ducts will lead to annual energy savings of 20 percent, cut peak demand, and improve occupant comfort.

What's Next

Several organizations are using the guide in training programs for mechanical systems designers. Elements of the guide, for example, appear in Pacific Gas & Electric's Building Operators Certification Training program. A condensed form of the guide is offered through the California Public Utility Commission's Energy Design Resources program (www.energydesignresources.com).

The guide's recommendations are being used in a new PIER project with Carrier Corp. to build and test an advanced rooftop HVAC prototype. The new unit's reliability and efficiency features will correct many of the field problems uncovered in the study. It will include an automatic fault detection system that is also being developed under the PIER program. The Consortium for Energy Efficiency (CEE) is also using information from the guide to improve the field performance of small HVAC systems.

Collaborators

Architectural Energy Corp. and the New Buildings Institute collaborated on this project.

For More Information

Detailed reports on this project can be downloaded from the Web at www.energy.ca.gov/reports/2003-11-17_500-03-082_A-12.PDF.

Contacts

New Buildings Institute, Cathy Higgins, higgins@newbuildings.org, 509-493-4468

Architectural Energy Corp., Pete Jacobs, pjacobs@archenergy.com, 303-444-4149

California Energy Commission, Nancy Jenkins, njenkins@energy.state.ca.us, or visit www.energy.ca.gov/pier/buildings

About PIER

This project was conducted by the California Energy Commission's Public Interest Energy Research (PIER) program. PIER supports public-interest energy research and development that helps improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

For more information visit www.energy.ca.gov/pier

CEC-500-2005-046-FS
021705